U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: HELICOPTER DYNAMIC ROLLOVER

Date: 1/27/86
Initiated by: AFS-840

AC No: 90-87
Change:

1. PURPOSE. To familiarize the helicopter pilot/instructor and pilot school personnel of the hazards associated with dynamic rollover.

2. BACKGROUND. An increasing percentage of helicopter accidents are being attributed to dynamic rollover, a phenomenon that will, without immediate corrective action, result in destruction of the helicopter and possible serious injury. This advisory circular informs helicopter flightcrews of the cause of helicopter dynamic rollover and measures to take to prevent such occurrences.

3. DISCUSSION. Helicopter pilots in general are required to be skillful in operations on both improved or unimproved surfaces. During normal or slope takeoffs and landings with some degree of bank angle or side-drift with tie skid/wheel on the ground, the bank angle or side drift can place the helicopter in a situation where it is pivoting (rolling) about a skid/wheel which is still in contact with the ground. When this happens, lateral cyclic control response becomes more sluggish and less effective than for a free hovering helicopter. Consequently, if a roll rate is permitted to develop, a critical bank angle (the angle between the helicopter and the horizon) may be reached where roll cannot be corrected, even with full lateral cyclic, and the helicopter will roll over onto its side. As the roll rate increases, the angle at which recovery is still possible is significantly reduced. The critical rollover angle is also reduced. The critical rollover angle is further reduced under the following conditions:

a. Right side skid down condition;

b. Crosswinds;

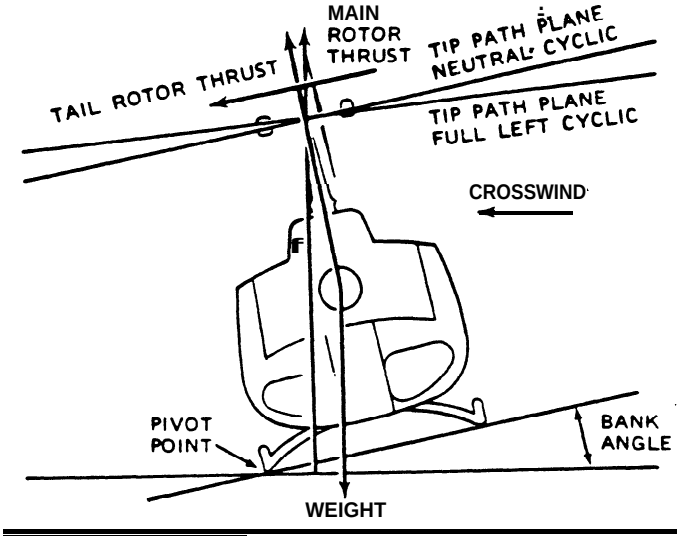
c. Lateral center of gravity offset;

d. Main rotor thrust almost equal to helicopter weight; and

e. Left yaw inputs.

4. CRITICAL CONDITIONS. When certain elements of helicopter operations are at or near their most critical condition, such as high gross weight, right lateral center of gravity, crosswind from the left, hovering with only the right skid/wheel in contact with the surface and with thrust (lift) approximately equal to the weight, very little right roll rate is correctable for any given bank angle. (See Figure 1.)

FIGURE 1. EXAMPLE OF FORCES ACTING ON A HELICOPTER WITH RIGHT SKID ON THE GROUND



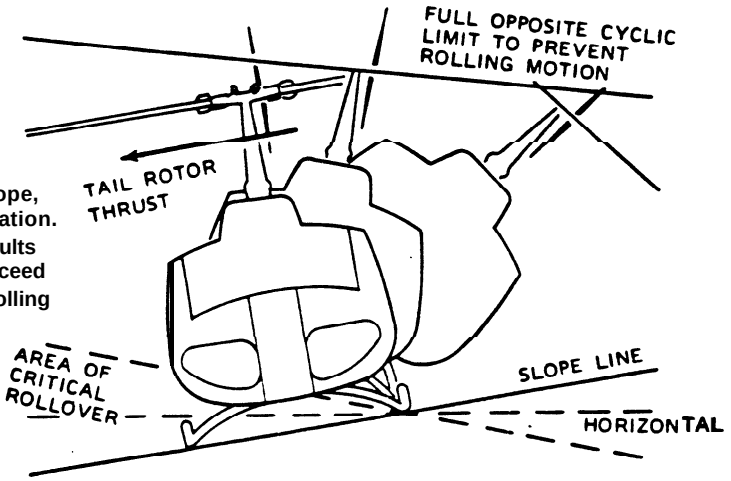
During normal takeoffs to a hover and landings from a hover, cross slope takeoffs and landings, and takeoffs from the ground with bank angle or side drift, a situation can exist where the helicopter will pivot about the skid/wheel which remains on the ground and enter a rolling motion that cannot be corrected with full lateral cyclic input.

5. CYCLIC TRIM. When maneuvering with one skid/wheel on the ground, care must be taken to keep the helicopter cyclic control properly trimmed (if equipped with force trim/gradient), especially laterally. For example, if a slow takeoff is attempted and the tail rotor thrust contribution to rolling moment is not trimmed out with the cyclic, the critical recovery angle may be exceeded in less than 2 seconds. Control can be maintained if the pilot maintains proper cyclic trim and by not allowing helicopter roll and pitch rates to become too great. The pilot should fly the helicopter into the air smoothly keeping excursions in pitch, roll, and yaw small and should not allow any untrimmed cyclic (force trim/gradient) pressures.

6. NORMAL TAKEOFFS AND LANDINGS. When performing normal takeoffs and landings on relatively level ground with one skid/wheel on the ground with thrust (lift) approximately equal to the weight, the pilot should carefully maintain the helicopter position relative to the ground with the flight controls. Maneuvers should be performed smoothly and the cyclic should be trimmed (force trim/gradient) so that no pitch or roll movement rates build up, especially roll rate. If the bank angle starts to increase to an angle of approximately 5° to 8° and full corrective cyclic does not reduce the angle, the collective should be reduced to diminish the unstable rolling condition.

7. SLOPE TAKEOFF AND LANDINGS. When performing slope takeoff and landing maneuvers, the published procedures should be followed and care should be used to keep roll rates small. The pilot should slowly raise the downslope skid/wheel to bring the helicopter level and then lift off. If landing, the pilot should land on one skid/wheel and slowly lower the downslope skid/wheel using combined movements of cyclic and collective. If the helicopter rolls to the upslope side (approximately 5° to 8°), the pilot should decrease collective to correct the bank angle and return to level attitude and then start the landing procedure again. (See Figure 2.1)

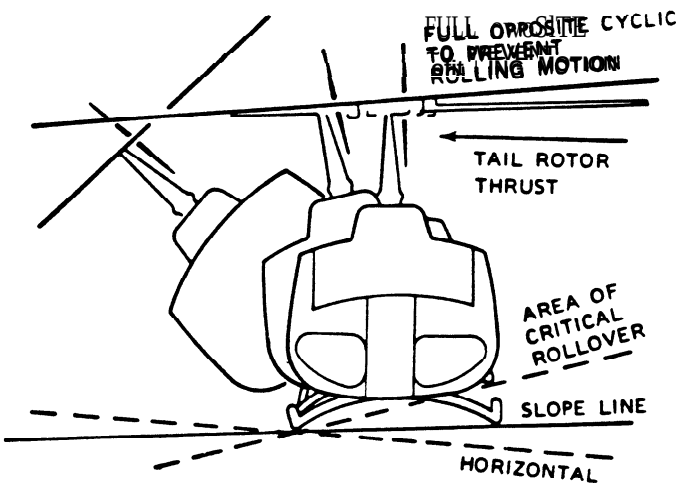
FIGURE 2. UPSLOPE ROLLING MOTION



Excessive application of cyclic into the slope, in coordination with collective pitch application. During landings or takeoffs, this condition results in the downslope skid rising sufficiently to exceed lateral cyclic control limits and an upslope rolling motion occurs.

8 USE OF COLLECTIVE. Collective is more effective in controlling the rolling motion than lateral cyclic because it reduces the main rotor thrust (lift), A smooth, moderate collective reduction (at a rate less than approximately full up to full down in 2 seconds) is adequate to stop the rolling motion. Care should be taken, however, not to dump collective at too high a rate thus causing fuselage - rotor blade contact. Additionally, if the helicopter is on a slope and the roll starts to the upslope side, reducing collective too fast may create a high roll rate in the opposite direction. When the uphill slope skid/wheel hits the ground, the dynamics of the motion can cause the helicopter to bounce off the upslope skid/wheel and the inertia can cause the helicopter to roll about the downslope ground contact point and over on its side. The collective should not be pulled suddenly to get airborne, as a large and abrupt rolling moment in the opposite direction will result. This movement may be uncontrollable. If the helicopter develops a roll rate with one skid/wheel on the ground, the helicopter can roll over on its side. (See Figure 3.)

FIGURE 3. DOWNSLOPE ROLLING MOTION



Excessive application of collective pitch in coordination with cyclic application into the slope. When the downslope skid is on the slope, excessive application of collective may result in the upslope skid rising sufficiently to exceed lateral cyclic limits and induce a downslope rolling motion.

9. HELICOPTERS AFFECTED. While this advisory circular primarily addresses the skid type helicopter, dynamic rollover can occur in either the skid or wheel equipped helicopter. All types of rotor systems, rigid, semi-rigid, or fully articulated are affected to some extent. Tail rotor thrust and wind drag on the fuselage contribute to roll moment. In helicopters that are equipped with main rotor systems that turn clockwise (when viewed from above), tail rotor thrust would be in the opposite direction and right pedal instead of left pedal control would increase that thrust.

10. PILOT TECHNIQUE. When landing or taking off, with thrust (lift) approximately equal to the weight (light on the skids or wheels), the pilot should keep the helicopter cyclic trimmed (force trim/gradient) and prevent excessive helicopter pitch and roll movement rates. The pilot should fly the helicopter smoothly off (or onto) the ground, vertically, carefully maintaining proper cyclic trim. Techniques for takeoff and landing are basically the same for all helicopters when avoiding conditions that would muse dynamic rollover. They are as follows:

a. Less lateral cyclic control will be available during crosswind operations when the wind is caning from the upslope direction.

b. Tailwind conditions should be avoided when conducting slope operations.

c. When the left skid/wheel is upslope, less lateral cyclic control will be available due to the translating tendency of the tail rotor.

d. If passengers or cargo are loaded or unloaded, the lateral cyclic requirement will change. If the helicopter utilizes interconnecting fuel lines that would allow fuel to automatically transfer from one side of the helicopter to the other, the gravitational flow of fuel to the downslope tank could change the center of gravity, resulting in a different amount of cyclic control application to obtain the same lateral result.

e. Care should be exercised so that the cyclic limits are not reached, resulting in mast bumping. If the cyclic control limit is reached, further lowering of the collective may cause mast bumping. If this occurs, the pilot should return to a hover and select a landing point with a lesser degree of slope.

f. During a takeoff from a slope, if the upslope skid/wheel starts to leave the ground before the downslope skid/wheel, the pilot should smoothly and gently lower the collective and check to see if the downslope skid/wheel is caught on sanething. Under these conditions vertical ascent is the only acceptable method of lift-off.

11. LEVEL, PAVED SURFACES. Dynamic rollover can occur on level surfaces as well. There are documented reports that indicate a skid/wheel has been caught on a fixed object of the ramp, or stuck with ice or in soft asphalt, and resulted in rollover. Failing to remove a tiedown or skid securing device has caused dynamic rollover.

12. FLOATING PLATFORMS. Reports have been submitted indicating the probable cause of accidents involved flight operations of helicopters on a floating platform. If the platform is pitching/rolling while attempting to land or takeoff, the result could be dynamic rollover.

William T. Brennan
Acting Director of Flight Standards